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NEW HAMPSHIRE COLLEGE
Agricultural Experiment Station
IN COÖPERATION WITH THE
State Board of Agriculture
AND THE
Bureau of Entomology, U. S. Department of Agriculture

THE BROWN-TAIL MOTH

By E. Dwight Sanderson
State Nursery Inspector and
Entomologist of the Station

AND

THE GIPSY MOTH

By Dr. L. O. Howard
Chief of Bureau of Entomology, United
States Department of Agriculture

IN NEW HAMPSHIRE IN 1906

NEW HAMPSHIRE COLLEGE
OF
AGRICULTURE AND THE MECHANIC ARTS
DURHAM

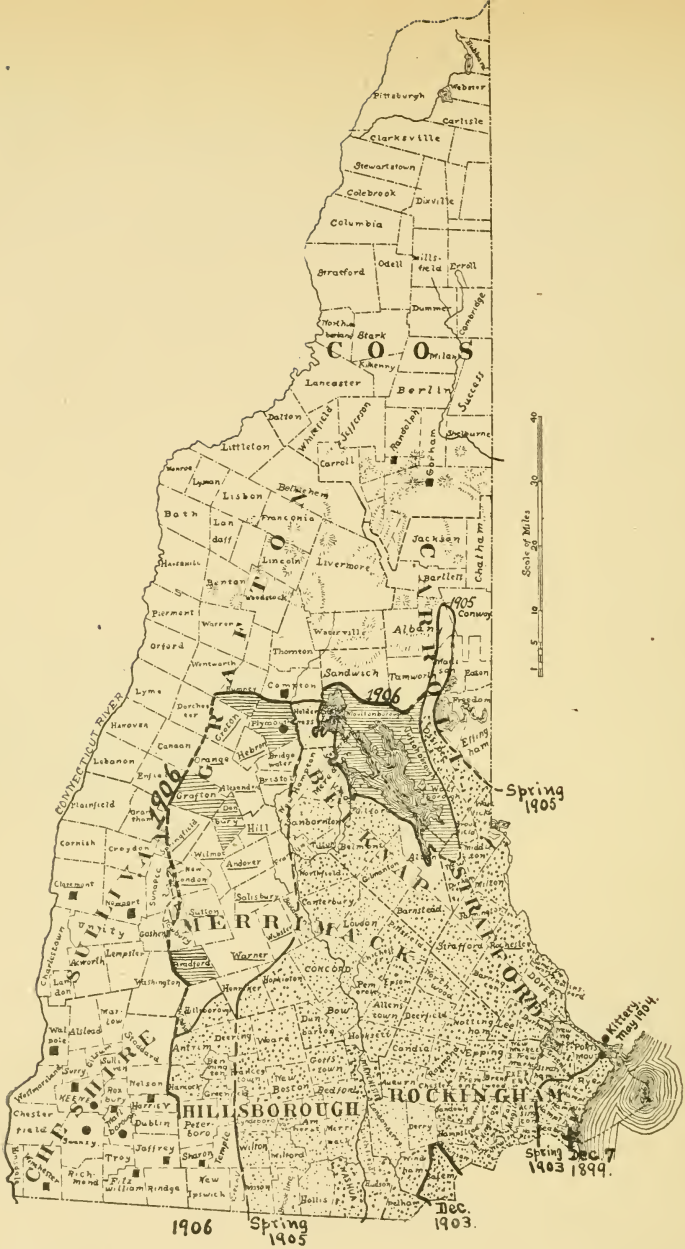


FIGURE 1. Map showing the gradual spread and distribution of the Brown-Tail Moth in New Hampshire. Dotted area infested in 1906. Heavy lines are outer boundaries of areas infested in years indicated at margin. Dash lines represent approximate boundaries not personally investigated, based on points infested north of them. Black circles show points examined in January, 1906, and found uninfested. Black squares show points examined in December, 1906, and found uninfested. Towns shaded with horizontal lines found infested in December, 1906, and those underlined within 1906 boundary are undoubtedly infested, though not personally examined.

THE BROWN-TAIL MOTH IN NEW HAMPSHIRE.

Spread and Present Distribution.

During July, 1906, the brown-tail moth continued to spread to the northwest into Grafton County, and north into Carroll County, but failed to spread westward into Cheshire County. Examinations made by an inspector of this station in November and December, 1906, show it to have spread over the area indicated in figure 1 in 1906. In those towns shaded the winter webs were found. The other towns within the boundary line connecting these towns were not examined but are undoubtedly infested. The following is a list of these towns, with those in which the webs were found marked with an asterisk.[1]

Grafton County.

Alexandria.
Bridgewater.
Bristol.
*Grafton.
Groton.
Hebron.
Orange.
*Plymouth.
*Rumney.

Sullivan County.

Springfield.

Carroll County.

*Sandwich.
*Moultonborough.
*Tuftonborough.
*Center Harbor.

Merrimack County.

Andover.
*Bradford.
*Danbury.
Hill.
Newbury.
New London.
Salisbury.
Sutton.
Warner.
Webster.
Wilmot.

[1] For the previous distribution and spread of the brown-tail moth in New Hampshire with a full account of its life history, remedies, etc., see Bulletin 122 of this Station.

In all twenty-five towns were probably newly infested during the summer or the area infested in New Hampshire increased about twenty per cent. On the north the moths crossed Lake Winnepesaukee and are not difficult to find along its northern shore and in southern Sandwich. The moths came into Meredith and Plymouth in large flights in mid-July. Webs were not found in Campton and it seems probable that the mountains with a scarcity of fruit and deciduous trees for food will make further spread much slower. Eight towns were examined in Cheshire County and Claremont and Newport in Sullivan County, but no webs were found.

Present Condition in Towns Previously Infested.

Throughout the coast towns where the moth has been longest and is therefore most abundant the heavy rains of May and June furnished ideal conditions for the growth of a fungus disease which destroyed thousands of the caterpillars. This disease was not so noticeable ten or fifteen miles back from the coast, and will probably be equally effective only under similar weather conditions, which are abnormal.

During January, 1906, there was a period of unusually warm weather, which it was asserted by the daily papers, would cause the young caterpillars to emerge from their winter webs. We were unable to find any which did so emerge and experiments conducted by us in subjecting winter webs to a greenhouse temperature and thus securing their emergence show that it would require a much longer period of such weather to cause the caterpillars to emerge even much later in the spring.

In general the winter webs are very much more abundant over the area infested in 1905 than they were a year ago. For even where the webs were almost entirely removed from fruit and shade trees in the winter of 1905 and 1906, the moths flew in July, 1906, from towns which had failed to

combat them, with the result that many towns which did good work in cleaning their trees of the webs a year ago must now do a larger amount of work on account of the neglect of neighboring towns.

Work Done by the Towns in 1905–'06.

In general there was but little complaint from annoyance by the brown-tail caterpillars in the early summer. This was due to the excellent work done by most of the towns and cities in destroying the winter webs. To determine just what had been done to combat the pest by the cities and towns of the state a circular letter was sent to the mayors and selectmen, from practically all of whom replies have been received, asking the following questions:

(1) What sum was appropriated for fighting the brown-tail moth in your town in 1906?

(2) How was this to be spent?

(3) What sum has been expended?

(4) Were the trees thoroughly cleaned of winter nests?

(5) Have the moths appeared during mid-July in larger numbers than in previous years, if so to what extent?

(6) Would you favor state legislation requiring property owners to remove the winter nests of the brown-tail moths from their trees, providing the cost of the work would not exceed one half of one per cent. the taxable valuation of the property and requiring the towns to see that this is done? This is the arrangement under which Massachusetts is now working and securing good results.

The replies of these towns which made any appropriation are summarized in the following table:

Town.	Appropriation.	Spent, 1905–'06.	How used.
Amherst	1c. per nest	$300.00	1 cent bounty.
Barnstead	$500.00	140.00	2½ cents bounty.
Bedford	1c. per nest	312.75	1 cent bounty.
Candia	100.00	65.00	Roadsides.
Chester	100.00	25.00	Roadsides; abandoned farms.
Chichester	100.00	30 00	1 cent bounty.
Concord		286.68	Street trees.
Contoocook	300.00	300.00	3 cents bounty.
Deerfield		273.47	1 cent bounty.
Durham	200.00	86.10	½ cent bounty.
East Kingston		54.23	½ cent bounty.
Epping		50.00	½ cent bounty.
Epsom		20.00	1 cent bounty.
Exeter	300.00	488.58	By selectmen.
Farmington	50.00	14.67	⅝ cent bounty.
Gilford		40.00	5 cents bounty.
Hampstead	150.00		
Hampton	200.00	50.00	By selectmen.
Hampton Falls	50.00	50.00	Road surveyors.
Hollis		12.00	By selectmen.
Hudson		116.25	½ cent bounty.
Laconia		110.00	Contractor.
Lee	100.00	50.00	Bounty.
Litchfield	50.00	50.00	⅝ cent bounty.
Loudon		35.06	1½ cents bounty.
Manchester		?	Street and park commission.
Mason		38.52	3 cents bounty.
Milford	200.00	75.00	Hired men.
Mont Vernon		38.66	½ cent bounty.
Nashua	500.00	500.00	Park commission.
New Boston	100.00	7.00	½ cent bounty.
New Durham		10.31	1 cent bounty.
Newington		10.00	By selectmen.
Newmarket	100.00	150.00	
Newton		35.00	½ cent bounty.
North Hampton		100.00	?
Northwood Narrows	50.00	50.00	⅝ cent bounty.
Penacook		23.54	?
Raymond	150.00	75.00	¾ cent bounty.
Reed's Ferry		280.68	1 cent bounty.
Rochester	75.00	77.50	Parks and city trees.
Rollinsford		40.00	⅝ cent bounty.
Somersworth	100.00	50.00	Hired men.
South Hampton		40.00	⅝ cent bounty.
Tilton		100.00	?
Windham		100.00	
Wolfeborough	200.00		
		$4,711.00	

The figures are somewhat misleading as the appropriations given are those made in March, 1906, while the amount spent represents that expended in 1905 and the spring of 1906.

In addition to the $4,711 spent by forty-seven towns reported, about $1,000 is known to have been used in cities and towns which have failed to report. So that probably nearly $6,000 was expended by cities and towns in New Hampshire in 1905–'06.

The following towns took no official action for the control of the pest, leaving it to property owners:

Allenstown.
Antrim.
Atkinson.
Auburn.
Barrington.
Belmont.
Bennington.
Bow.
Brentwood.
Brookfield.
Brookline.
Canterbury.
Danville.
Derry.
Dunbarton.
Francestown.
Fremont.
Gilmanton.
Goffstown.
Greenfield.
Hancock.
Henniker.
Hill.
Hillsborough Bridge.
Holderness.
Hooksett.
Kingston.
Londonderry.
Middleton.
Milton.
Northfield.
North Weare.
Nottingham.
Pelham.
Pembroke.
Plaistow.
Portsmouth.
Rye.
Salem.
Sandown.
Sanbornville.
Seabrook.
South Lyndeborough.
Strafford Centre.
Wilton.

Summarizing the replies to the other questions, twenty-one report the moths more numerous in 1906, and thirteen state them to be less numerous, the majority failing to report. The selectmen of fifty-six towns reply in favor of state legislation, while only eight are in any way opposed to it.

This shows most conclusively that although the work done by half of the towns was well done and most commendable, that unless all towns assist in the fight it will be difficult to control the pest, and the cost of control will increase unduly. Furthermore the method of paying bounties for the nests is hardly satisfactory. They are usually gathered

wherever found most abundant and are left where it is difficult and not worth the bounty to secure them. Is it not the duty of every property owner to clean his trees of this pest within a reasonable cost, and is there any reason why he should be paid for so doing? The large majority of replies from selectmen from all parts of the infested area show that public sentiment is strongly in favor of state legislation which will ensure the control of the pest in the best possible manner, making its control obligatory on every property owner and aiding the towns in their fight with an appropriation from the state.

FIG. 2.—Apple trees on Water Street, Somersworth, N. H., defoliated by brown-tail moth caterpillars in June, 1906.

Remedies.

Destroying the Winter Webs.

Cutting off and burning the winter webs (as described in Bulletin 122) is by far the most practical means of controlling the pest. The efficiency of their destruction was well shown in the City of Somersworth during the past summer. The city and private property owners had done most excellent work the previous winter in destroying the webs, but in one or two cases the ignorance or obturacy of the property owner prevented the destruction of the webs by the city employés. In one small yard with scarcely a dozen fruit trees where the webs were not destroyed the caterpillars appeared in such numbers that every apple tree was absolutely defoliated (see figure 2) and were gathered by the peck at the bases of the trees. Thorough spraying of the trees with arsenicals and spraying the caterpillars which had crawled on neighboring fences and houses with pure kerosene, destroyed most of them. But the expense was ten fold what it would have been to have pruned off the webs in winter, and enough caterpillars escaped destruction to reinfest the whole community. In another case a limb of a large apple tree (Fig. 3, *a*) overhung a neighbor's yard in such a way that it was difficult to remove the nests without entering the adjoining property. Permission to do so was refused. As a result this branch and another tree (Fig. 3, *c*) on the untreated property was defoliated, while the rest of the tree (Fig. 3, *b*), from which the nests had been removed, bore its normal foliage unmolested.

Spraying.

Frequently we are asked whether the caterpillars cannot be controlled by spraying. Spraying is effective if done early in May while the caterpillars are still young, but it is so much more expensive than to destroy the winter webs that it is rarely to be advised as the principle means of control of the brown-tail moth. When the eggs hatch in early

FIG. 3.—Apple trees defoliated by brown-tail moth caterpillars at Somersworth, N. H., June, 1906. From the main part of one tree, *b*, the webs were removed the previous winter, but were not removed from the limb *a* overhanging the next yard, which was therefore defoliated, while the rest of the tree remained practically unharmed. The other tree, *c*, was not pruned of webs and was also defoliated.

August and the young caterpillars skeletonize the leaves prior to forming their winter webs (see figures 4 and 5), they may be readilly killed by spraying with arsenate of lead or Paris Green. In the apple orchard there are numerous other caterpillars doing more or less damage to the foliage at this season which may be controlled by the same spraying, which therefore becomes a practice to be commended. Experiments made by us during the past season show that not less than five pounds of arsenate of lead to a barrel of water should be used, and that an increase to ten pounds per barrel merely results in killing the caterpillars a day or two quicker. Arsenate of lead is preferred on account of its unusual adhesive properties, remaining on the foliage several weeks after hard rains. Paris Green is very much quicker in its effect and is, therefore, to be preferred in some respects when there is no immediate prospect of rain. Care must be taken in the use of Paris Green that plenty of lime be added to prevent burning of the foliage, while arsenate of lead may be used in large quantities without danger in this regard. Our experiments indicate that

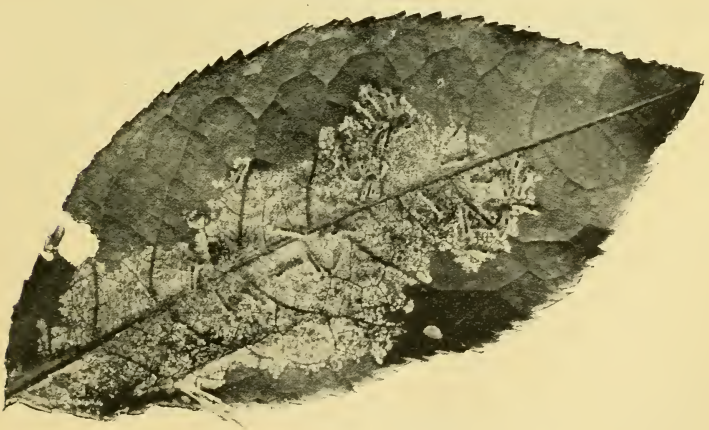


FIG. 4.—Newly hatched brown-tail moth caterpillars feeding on upper surface of apple leaf—enlarged.

a half pound of Paris Green per barrel will kill the caterpillars as quickly as ten pounds of arsenate of lead, but it does not follow, therefore, that Paris Green is to be preferred, as the other factors above mentioned must be considered.

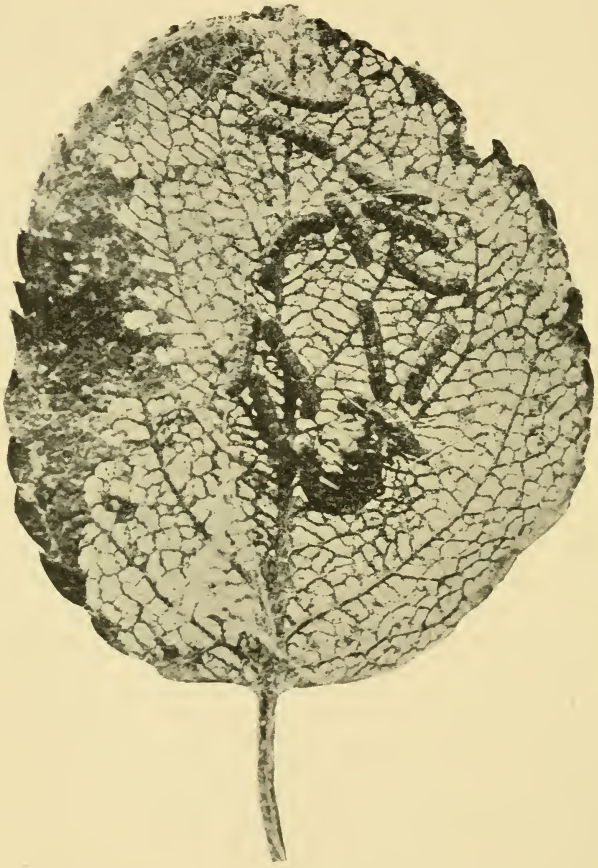


FIG. 5.—Young brown-tail moth caterpillars which have skeletonized an apple leaf in early September. Greatly enlarged.

THE GIPSY MOTH.

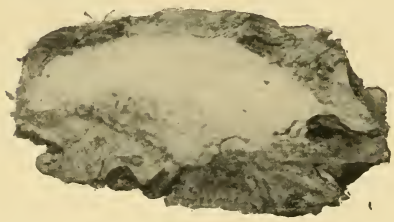
Since the publication of Bulletin 121 announcing the presence of the gipsy moth in New Hampshire, nothing has been done toward its control, owing to lack of funds or legislation authorizing such work. The towns infested or thought to probably be infested were urged to make appropriations to secure inspectors and exterminate the pests wherever found, but only Hampton Falls did so. Since July, 1906, all work against the gipsy moth in New Hampshire has been done by agents of the bureau of entomology, United States department of agriculture. Dr. L. O. Howard, chief of the bureau, has therefore kindly prepared a statement of the present status of the pest in this state. Citizens of southeastern New Hampshire are coming to appreciate, through personal experience, the seriousness of the brown-tail moth caterpillars, but in many respects the gipsy moth is a much more serious pest. It defoliates the trees in June, when it is much more difficult for the tree to put out new leaves and it is more injured than by defoliation by the brown-tail caterpillars earlier in the spring. Again, the gipsy moth caterpillar attacks pines and all coniferous trees. While several consecutive strippings are usually necessary to cause the death of a healthy deciduous tree, one thorough stripping will kill the white pine and other coniferous trees.

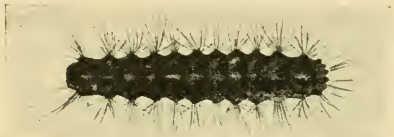
Heed should be given, therefore, to Doctor Howard's discussion of "What Should Be Done in New Hampshire" (page 227). If we now appreciate the necessity for the better control of the brown-tail moth, which has been unwisely neglected, should not this experience show the folly of neglect to attempt the immediate control of the gipsy moth, which is a much more serious pest, and point to the wisdom of immediate action?

E. Dwight Sanderson.

THE STAGES AND LIVES OF THE GYPSY MOTH

Stages.	Gypsy Moth.
Egg Cluster	Usually on bark of tree; very rarely on leaf. Robust, 1½ to 2 inches long. Light yellow or creamy. From August to May.
Caterpillar. Full grown	Dark grayish or sooty. Double row of five pairs of blue, followed by six pairs of red spots along back.
Moth. Female	Wings spread 2¼ in. Dingy-white, lightly streaked and blotched with blackish. No brush of brown hairs at tip of abdomen. Does not fly, crawls.
Winter Passed	In egg stage—see above. Never as a caterpillar.
Irritation of Human Skin	Not caused by any stage.

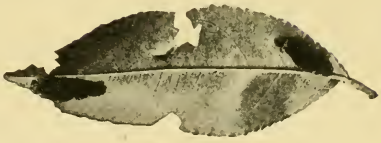
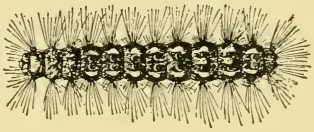


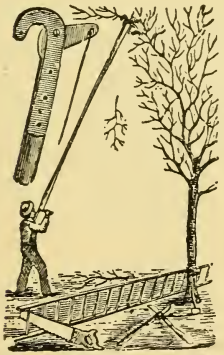


Most Effective Means of Control.

Soak eggs with creosote in fall, winter, or spring.

AND BROWN-TAIL MOTH CONTRASTED.

Brown-Tail Moth.	Stages.
Always on under side of leaf. Smaller and more slender. Dark or golden brown. July.	Egg Cluster. 
Bright tawny or orange. A conspicuous row of pure white spots or dashes along each side of body. Only two bright red spots on middle line at lower end of back.	Caterpillar. 
Wings spread 1½ inches..... Pure snow white.	Moth, Female.
A conspicuous, sharply contrasted, thick tuft or patch of golden or brownish hairs at tip of abdomen. A swift, strong flyer, by night, and attracted to lights.	
As small caterpillars in a silken web or nest on tips of twigs, from which they crawl out in spring.	Winter Passed.



Irritation.

Hairs from caterpillars, which are often transferred to cocoons and moths, cause an annoying and painful irritation of the skin.

Most Effective Means of Control.

Cut off and burn webs in winter.

THE PRESENT CONDITION OF THE GIPSY MOTH IN NEW HAMPSHIRE.

In the fall of 1905 a rough scout of the seacoast towns of New Hampshire which are most accessible by through travel from the areas in Massachusetts most infested by the gipsy moth was made by two men employed in the work for a few weeks only. In the course of this scout the moth was discovered in all of these towns from the Massachusetts line to Portsmouth, but always in small colonies only. This work was done under the direction of Professor Sanderson, at the expense of the state of New Hampshire, and one of the inspectors was borrowed from the Massachusetts force engaged in the work of suppressing the gipsy and brown-tail moths.

The appropriation of the general government became available July 1, 1906, and in the latter part of that month scouting work was begun by government employees in New Hampshire. One man was sent to the state at first and on August 12 another was furnished. Systematic scouting was at once begun in the towns in which the moth was discovered the previous year, with the following result: In Seabrook were found twenty colonies and more than 300 egg-clusters; in Hampton Falls fifteen colonies and a total of 140 egg-clusters; in Hampton nearly sixty colonies and over 550 egg-clusters; in North Hampton over forty colonies and about 400 egg-clusters, and in Rye about seventy-five colonies and over 1,400 egg-clusters.

Curiously enough, this record would seem to indicate that the gipsy moth is more plentiful as the distance increases from the badly infested centers in Massachusetts, but this cannot be taken as a sound generalization, since when the scouting commenced in late July there were still many of the caterpillars crawling, and there are undoubtedly very many egg-clusters in the first named towns which

FIG. 6.—Map showing gradual spread and present distribution of the Gipsy Moth, except York, Kittery, and Eliot, Maine.

have been laid since the scouts investigated that territory. In the town of Greenland ten or twelve colonies have been discovered and about forty egg-clusters, but the whole town has not yet been covered.

All of this scouting was done prior to November 1, and since the leaves had not fallen from the trees at that date the most efficient scouting could not be done. Later work has indicated that in Newcastle there are five colonies and some forty egg-clusters. The scouting force was increased from two to seven men about November 1, and the City of Portsmouth was thoroughly examined. In this city were found nearly forty colonies and about 175 egg-clusters.

This is the extent of our actual knowledge at the present time. It is stated by persons perfectly familiar with the gipsy moth that this species has been seen in Manchester and in Hooksett, the next town north of Manchester. The truth of these statements is now being investigated.

After the scouting work had been completed in Portsmouth, the whole party was sent across into Maine, and the New Hampshire work was temporarily dropped. At the present date of writing five men have been returned to New Hampshire with instructions to scout the cities of Concord, Manchester and Nashua, working easterly from Nashua, taking the towns in order along the Massachusetts line. The scouting party will be increased if necessary.

Should the reports from Manchester and Hooksett prove to be correct, there is a possibility that the entire territory from Manchester to the ocean has the gipsy moth scattered through it. It is the opinion of Mr. D. M. Rogers, in charge of the government field work, however, that this whole territory is probably not infested. There are some towns in this district which have no railroads—neither steam nor electric—and several which have very little communication with the territory from which the moth could readily be introduced. Mr. Rogers is of the opinion that twenty-five or more towns will prove to be infested and he also insists upon the possibility of discovering the presence of the moth

at many of the principal summer resort places. Pointing out the very considerable automobile traffic from Boston and its vicinity to Lake Sunapee and Lake Winnepesaukee and the White Mountains, and also the very considerable transportation of goods by rail for vacation outings, he considers the possibility a strong one.

The character of the infestation in the regions where the moth has been found is not such as to have resulted as yet in any considerable damage. The colonies are all small, but nevertheless there is a great deal of work necessary to prevent the increase and further spread of the moth. The infestation is not confined to any particular section in any of the territory but it is scattered in nearly all sections, including both village and farm property. It is interesting to note that the scouting parties have discovered but one colony in the woodlands, namely on Chapel Street in North Hampton. Several of them, however, are quite near to forest growth, and a more careful search may possibly show them to be beyond the present known bounds. For the most part in the territory covered the insects are confined to apple orchards. There are very few street trees in all of this section on which the insect has been found, and on none of them were there many specimens.

What Should Be Done in New Hampshire.

When we consider what has happened in Massachusetts in the way of damage to property, and when we consider further the enormous amounts which it is necessary to spend in that state annually at the present time simply to hold the gipsy moth in check, it seems to the writer that New Hampshire should undoubtedly aim at the extermination of the insect within her borders. Should it gain such a foothold in New Hampshire as it has in Massachusetts, the amount of money required to even hold it down will prove a very serious burden to the financial resources of the state. The government will go on with its inspection work

Fig. 7.—A piece of woodland at Arlington, Mass., typical of many, killed by defoliation by Gipsy Moth caterpillars in 1904. Taken March, 1905.

until every locality in the state is definitely known. The destruction of isolated colonies will also be undertaken, but the state should make provision for a certain proportion of the work and should adopt a law similar to the law now in force in the state of Massachusetts in order that exterminative work may properly be enforced and in order that the state may not be left defenseless should the appropriations by the general government be insufficient in the future as at present to handle the whole case, or should they lapse entirely. A law based upon that of Massachusetts will also enable New Hampshire to handle the brown-tail moth question, and, as explained in various publications of the bureau of entomology of the United States department of agriculture, the government campaign against this latter insect can at no time assume much more than educational proportions, since the actual prevention of the spread of this insect into new territory now seems not to be feasible.

Cost of Work Against the Gipsy Moth.

As the result of a very considerable experience, Mr. Rogers estimates the cost of work against the gipsy moth in a general way about as follows:

For preliminary scouting work from $100 to $150 per town; for effective work like fall and winter cleaning, cutting the brush and worthless trees, putting on burlaps and attending them for two months, he estimates at about $1,000 per town; while the more exacting work, looking towards extermination, which would require a careful inspection after the cleaning, spraying in some of the bad places, cementing and tinning holes in trees, and following all phases of the work every month in the year, he estimates at about $2,000 per town.

The details of the expenses of the moth work may be estimated about as follows, basing them upon a cost of $2 per day of eight hours for each laborer, 10 to 12 cents per pound for arsenate of lead, and one and one-half cents per yard for 8-inch burlap:

Cost of spraying average orchard trees, from 20 to 25 cents per tree. Cost of spraying average street trees, from 40 to 50 cents per tree. Cost of burlapping and attending, about 20 to 25 cents per tree for the season of from six to eight weeks. Cost of banding the trees with Tanglefoot or similar substance, 5 to 10 cents per tree; and an additional cost for patrolling to kill the caterpillars. Cutting the brush and poor trees, pruning and treating egg-clusters varies in cost very widely according to the growth, and amounts all the way from $10 to $100 per acre. An average native growth of from twenty-five to thirty years around Boston can be cut and put into cordwood for about $40 per acre, and the ground may be burned over with the brush after the wood has been removed for from $2 to $5 per acre.

L. O. Howard.

Fig. 8.—Killing the eggs of the Gipsy Moth in woodland, showing the large amount of labor and expense involved in combating the pest in badly infected districts. (After Forbush and Fernald.)

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